Technical notes

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Two dimensional perfusion angiography in brain arteriovenous malformation: technical considerations

Abstract

The two-dimensional tissue perfusion, in digital subtraction angiography, has been shown as a useful tool in the study of ischemic vascular lesions, being a framework for quantitative analysis and visualization of infusion parameters, benefitting the vascular malformations of the values obtained with this tool. The conduct of such a study is reported for the first time in Cuba in a patient diagnosed with arteriovenous malformation of cerebellum, determining factors that guide personalized therapy in situ, with prognostic value according to the treatment used, without additional exposure to radiation or increased contrast dose; so its validation would be of added interest in practice.

Keywords: brain perfusion, two-dimensional angiography, arteriovenous malformation

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Abbreviations: DSA, digital subtraction angiography; CT scan, computed tomography scan; AVM, arteriovenous malformation; 2D, two dimensional

Introduction

Technological advances in imaging during the past decade led to a radical change in the practice of vascular surgery, accelerating the passage of conventional vascular procedures to endovascular approaches. They have now become the support for the development of these procedures, increasing their complexity.[1] That is why this technological leap has led to the creation of operating rooms that allow in unison the use of minimally invasive techniques along with conventional surgery.[2]

Digital subtraction angiography (DSA) has limitations related to the quality of the images, obtained on a greyscale, and table by table should be examined in order to observe the temporal differences. This article addresses these limitations by presenting perfusion angiography as a framework for quantitative analysis and the visualization of infusion parameters and delay of DSA. Its usefulness can be attributed to its good time-spatial resolution and that is not easily compatible with other acquisition techniques such as magnetic resonance imaging and computerized tomography.[3] The two-dimensional tissue perfusion angiography image is obtained through software integrated into the computer that allows two-dimensional functional information based on DSA. It provides the interventionist with the tool that allows measuring, in real time, the impact of the treatment performed and helps determine the right time to complete it. From these observations, the general objective of this article is to describe the usefulness of the perfusion parameters that can be extracted from that study and to be shown in colour-coded images that can be easily interpreted by neurologists, neurosurgeons, and neurointerventional radiologists.

Case report

A 26-year-old female patient, Karnofsky index[4] 90 points. She abruptly presented intense headache, vomiting, and photophobia. In the initial brain computed tomography (CT scan), haemorrhage is objective in the left cerebellar hemisphere, entering the Intensive Care Unit. At 24 hours, it presents degradation of the state of consciousness due to obstructive triventricular hydrocephaly. It is decided to place peritoneal ventricular derivative system with medium-pressure opening valve and evidence of neurological event resolution. Within 15 days of the onset of symptoms in the study of Angio CT scan, arteriovenous malformation (AVM) is diagnosed in the left cerebellar hemisphere, DSA (Figure 1 A, B and C) and two-dimensional tissue perfusion are performed (Figures 2 & 3).

Technique

We use standard brain angiography methods with percutaneous access by modified Seldinger technique, to the right femoral artery by retrograde puncture. Spinal catheter 5 Fr was used for selective intubation of each vertebral artery. After positioning the angiographic catheter, contrast was injected (10 ml Iopamidol 370, Unique Pharmaceutical) at a range of 5 mL/sec. with a programming of 3 images/sec. with Mark 7 Arterion automatic injector pump. The record is continued until the opacification of the major cerebral venous sinus is visualised. The time density curves are automatically calculated from DSA images with parametric colour encoding that allows the extraction of post-procedure data (Figures 2 & 3).

Two dimensional (2D) perfusion brain angiography made it possible to visualize apparent blood flow, blood volume, and average transit time. Observing a high-flow AVM in the left cerebellar hemisphere, small (maximum diameter 28.23mm), given by its rapid filling (0.7 seconds) and the visualization of early venous drainage in the early arterial phase, recruiting a considerable volume of blood taking into account the distribution of the iodized contrast used according to the parametric flow scale, with greater uptake and permanence of the contrast in the torch of the lesion, which lasts throughout the arterial phase (3.7 seconds), appreciating even in the late venous phase.

Exposure to radiation during DSA and 2D perfusion cerebral angiography under radiological protection measures:

Kerma dose in accumulated air: Front 525.05 mGy, Lateral o.oo mGy

Cumulative area dose product (PDA): 114191 mGy/cm2

Fluoroscopy time: 04:05 minutes

Discussion

The two-dimensional tissue infusion angiography technique, hereinafter 2D tissue perfusion, is based on standard DSA with a frame rate of three to six pictures per second. Two-dimensional perfusion images are obtained through automatic reconstruction with post-processing software on a dedicated workstation (Philips Allura Xper FD20 and Interventional Workspot, Philips Medical SystemTM). The technique requires the acquisition of additional software, induces minimal additional exposure to radiation, and uses a safe contrast dose for the patient, being able to standardize its use without increasing the time or cost of proceeding.[5]

The software to analyze the perfusion is based on a calculation of the change of density per pixel over time with images obtained before and after the endovascular or surgical procedure.[6] Two-dimensional tissue perfusion angiography contains temporary information that can be used to track the contrast agent and calculate tissue perfusion parameters such as: brain blood volume, brain blood flow, average transit time, and maximum peak flow time, which provides a semi-quantitative evaluation of brain haemodynamics (Graph 1).

Measured parameters

Arrival time: Time from the beginning of the measurements to the beginning of the contrast operation. It allows you to evaluate changes in blood flow speed before and after treatment. Time to maximum value or time to Peak: Reflects the flow rate of most contrast (compared to the fastest contrast as measured by arrival time): short peak time suggests high flow rate. Area under the curve: When the amount of contrast remains constant in the region to be treated, the volume of blood flow occupied by the injury is estimated. Average transit time: Measurement of the duration of the average contrast time, taking into account asymmetry between regions. The difference in the pre-proceder and post-proceder infusion is best demonstrated by changing the area under the curve and changing the maximum density (Figure 1). [7]

Image analysis: Most magnetic resonance imaging contrast brain perfusion studies focus on signal intensity changes that accompany the passage of a paramagnetic contrast agent through the cerebral vascular system, obtaining information on blood volume and flow,[8] being one of the most used techniques to assess the characteristics of tissue perfusion in biological tissues, this includes vascular permeability, tissue perfusion, and expansion of intravascular and extravascular spaces based on series of T1-weighted images, acquired before, during, and after intravenous injection of the contrast agent.[9,10]

Unlike infusion images in magnetic resonance imaging and computerised tomography, which have been studied in clinical trials, such as DEFUSE, the value of parametric DSA images has been greatly underestimated.[11] 2D tissue perfusion angiography with flat detector technology has been successfully applied in neurointerventional procedures related to the treatment of acute ischaemic stroke. The application allows the evaluation of brain blood volume in patients with acute stroke and can predict the final volume of the infarction, improving the management of these patients.

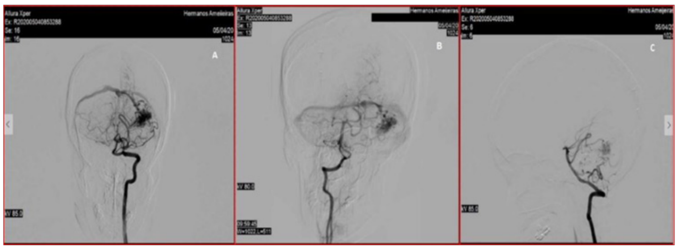

Figure 1 Arteriography by digital subtraction. Injection from left and right vertebral territories. A-Vista frontal, B-oblicua and C- lateral, respectively. The VMA vascular buckle is visualised, in this case with high flow with multiple aferences from the posteroinferior cerebellar artery (PICA), anteroinferior cerebellar artery (AICA) and upper cerebellar artery, with early venous drainage to left transverse sinus already evident from the arterial phase itself.

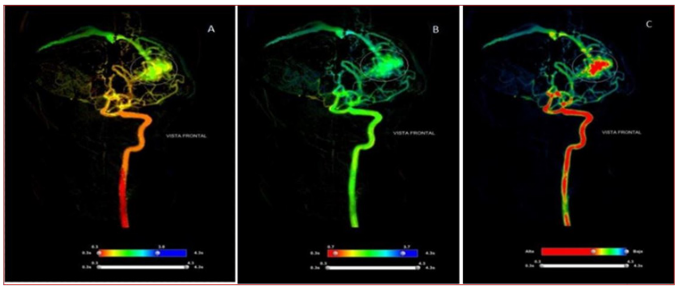

Figure 2 Tissular perfusion by two-dimensional angiography of arteriovenous malformation in the left cerebellar hemisphere. Front view with a parametric flow scale.

Parameters: A, arrival time; B, time to peak contrast; C, absorption index and D, area under the curve

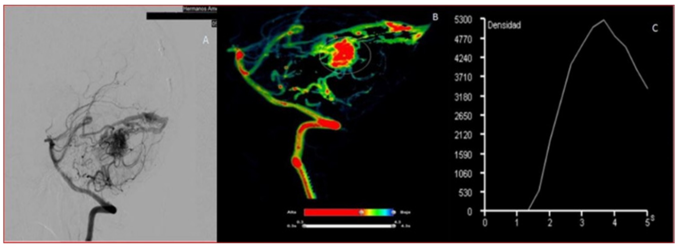

Figure 3 Side View Sequence of VMA in the left cerebellar hemisphere: A-Angiography by digital subtraction, B- 2D tissue perfusion by angiography and C-Curva density as a function of time, relative to the Maximum Absorption Index.

2D tissue perfusion angiography studies in the brain vasospasm have been reported by different authors. Levitt and collaborators analyzed the results of the infusion images using the Philips Allura workstation in eight vascular territories in four patients to evaluate the radiographic response to vasospasm treatment.[12] In addition, Gölitz and collaborators report the use of the Leonardo workstation (SiemensTM) and the iFlow system to evaluate the angiographic response of treatment for intra-arterial Nimodipine treatment in 17 patients.[13]

However, after an extensive bibliographic search (Medline, Scielo, Pubmed, Cochrane), it is the first time Cuba has been reported, the use

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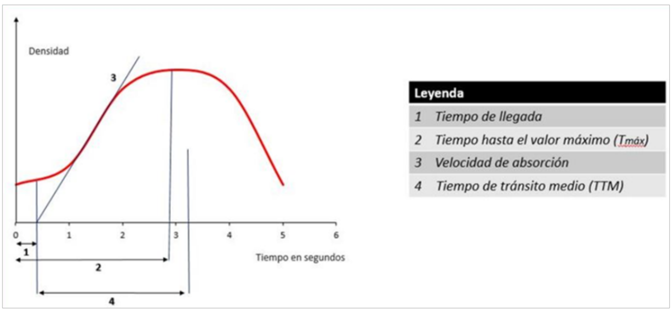
of the 2D angiography perfusion technique in a cerebral arteriovenous malformation, providing data that allow characterizing the flow pattern of such injury. This technique is capable of facilitating the opportunity, in real time, to confirm the effects of endovascular treatment before finalizing the procedure to achieve the best possible result.[14]



Graph 1

The interpretation of these images could benefit from colour-coded infusion parameters that would allow the visualization of hemodynamic characteristics that are not directly detectible in standard on-the-fly angiographs and would therefore allow personalized decisions to be made and without delay in medical behavior.[3] Therefore, the validation of 2D tissue perfusion angiography for the estimation of a priori results during endovascular interventions would take great interest in clinical practice.

Strengths and limitations of the study

The numbers of patients were small.

Conclusion

Real-time two-dimensional tissue perfusion angiography is feasible and provides a reliable semi-quantitative measurement of blood flow in vascular lesions, extending its use not only to ischemic lesions, but to AVM as an evaluative tool.

Recommendations

Standardize in the study of cranial AVM the performance of tissue perfusion by two-dimensional angiography, as a pre- and post-endovascular evaluation method.

The future uses of this technique could provide guidance for the duration and dosage of treatments based on individual infusion parameters during angiographic studies.

One of the most promising lines of research would be to perform a comparative analysis to evaluate the equivalence of the parameters estimated from two-dimensional tissue infusion angiography with that obtained by the magnetic resonance imaging or CT scan study.

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None.

Conflicts of interest

The authors declare no conflicts of interest.

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